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Distributional Effects of the European Emissions Trading System and the Role of Revenue Recycling

Empirical evidence from combined industry- and household-level data

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Distributional Effects of the European Emissions Trading System and the Role of Revenue Recycling

- Empirical evidence from combined industry- and household-level data -

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Abstract: We calculate the expected distributional effects of the European Emissions Trading System combining industry and household-level data. By combining data on direct CO_2 emissions by production sector from the German Environmental Account with the German Input-Output Accounts, we calculate the CO_2 intensity of each sector covered by the EU ETS. We focus on the impact of price increases in the electricity sector, both directly in the form of higher electricity bills for consumers and indirectly through products that use electricity as an input to production. Distributional effects of price increases are analyzed on the basis of the German Income and Expenditure Survey for the year 2008 data and updated to 2013. We confirm the ex-ante expected regressive effect, which is, however, both rather small in magnitude and can be offset and even more than offset by revenue recycling, in particular the reduction of social security contributions on labour income.

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1 Introduction

Even though the Climate Summit in Durban of 2011 merely kept the door open for further negotiations regarding the adoption of a new global climate treaty, pollution control policies already are a reality in Europe and around the world. In order to reach the goal of reducing emissions by 20% below 1990 levels until 2020 the European Emissions Trading System (EU ETS) has been introduced and been operational since 2005 (European Union, 2003).

Since the price of permits increases the cost of production for emissions-intensive industries, such as electricity generation or the manufacture of glass and paper, consumer prices are likely to rise as a consequence. While this is indeed desirable, since it induces a shift away from polluting goods to less energy-intensive ones, concerns have been raised as to whether those price increases might predominantly hurt low-income households, since they spend a larger fraction of their income on emissions-intensive products than high-income households.

While this effect has been confirmed in the literature, researchers have noted the possibility to alleviate potential adverse distributional effects by way of revenue recycling. Metcalf (1999) who models a revenue-neutral green tax reform in the U.S. finds that while the burden of the environmental tax is distributed regressively, the whole reform is much less so and can even be rendered progressive by targeting low-income families. In their analysis of a 15% decrease in carbon emissions by way of an emissions trading system in the U.S., Dinan and Rogers (2002) compare both efficiency and equity effects of a system where those permits are given out for free to one where they are auctioned and the revenue returned either as a cut to corporate taxes, payroll taxes or as lump-sum transfers. They come to the conclusion that unless the government auctions most of the permits, and returns them in equal lump-sum transfers, this policy is highly regressive and note the trade-off between using revenues to increase efficiency of the tax system and using them to alleviate regressivity. Burtraw et al. (2009), who model a hypothetical emissions trading system in the U.S. with a price of $21 per ton of carbon in 2015, find that returning revenue in the form of per capita lump-sum transfers to households, especially if these are taxable, makes the policy progressive. The same is true if revenues are returned as an expansion of the personal income tax credit. A reduction of the income tax and payroll tax, albeit favoured for efficiency reasons, exacerbates the regressivity of an emissions trading system. In their recent study of a domestic emissions trading system in Canada, Araar, Dissou and Duclos (2011) combine a general equilibrium model with stochastic dominance analysis to assess its impact on welfare and inequality under three different policy instruments: an output-based allocation of permits, revenue recycling in the form of lower payroll taxes and revenue recycling in the form of lower consumption taxes. While they find that inequality increases under all three scenarios as compared to the base case, they report rather modest effects, which are significant for the output-based allocation and reduction in payroll taxes and insignificant for the reduction in consumption taxes.

Studies have also been carried out for European countries. Baker and Köhler (1998) who study the effect of excise duties used to cut emissions by 10% in eleven EU member states, find that this policy is weakly regressive if revenues are used to reduce employers' taxes, but becomes strongly progressive if revenues are distributed lump-sum. Modelling a hypothetical CO_2 tax of €20/tCO_2 for Ireland, Callan et al. (2008) also find that the initial effect is regressive, but that households across the income distribution can be made better off, if revenues are partly passed back to them. They implement different forms of recycling the revenue, such as an increase in social security payments, an increase in the personal tax credit, or a reduction of the tax rate and note that the increase in social security payments is the most progressive of the options. In their study of the Danish CO_2 tax Wier et al. (2005) find that it is regressive (especially its direct component) and even more so than other Danish levies, such as the value added tax (VAT). They note the importance of family size and regional differences. Brännlund and Nordström (2004) consider a doubling of the Swedish CO_2 tax, where revenue is returned in form of a lower VAT or a subsidy to public transport. They find that the reform is regressive, but point out that regional differences are more important than differences in income. Bach et al. (2001) carry out a broad-based analysis of the German environmental fiscal reform of 1999, which increased taxes on fossil fuels and electricity and in turn lowered social security contributions (SSC). As part of a larger fiscal reform, income tax and child benefits were also adjusted. Overall, they find only moderate effects. When taken in isolation, the introduction of the environmental tax is regressive, looking at the whole reform package, most households are better off than before the reform. Interestingly, there exist a number of studies for European countries (Labandeira and Labeaga 1999 for Spain; Tiezzi 2005 and Martini 2009 for Italy; Symons et al. 2002 for five European countries), which find that carbon taxes in those countries are not necessarily regressive, even before revenue is returned to households.

Although the effects of a carbon tax are often comparable to those of an emissions trading system, as a cornerstone of European environmental policy, the European Emissions Trading System (EU ETS) merits differential analysis. We are not aware of any study to date explicitly modelling the impact of the EU ETS on households in a European member state using real world data. As the EU ETS is due to enter its third phase in 2013, such an analysis seems warranted, as this will be the first phase during which a large amount of emission permits will be auctioned rather than given out for free, thus presenting European governments with the opportunity to alleviate unwanted distributional effects by way of revenue recycling.[1]

This paper contributes to the empirical evaluation of the expected distributional effects of the EU ETS by combining industry and household-level data for Germany. We focus on the impact of price increases in the electricity sector, both directly in the form of higher electricity bills for consumers and indirectly through a whole range of products that use electricity as an input in production. For our analysis, we combine industry- and household-level data in order to calculate the expected distributional effect of the EU ETS on German households, as described in the next section. Our simulation results confirm the ex-ante expected regressive effect the EU ETS has on households. However, the initial regressive effect is both rather small in magnitude and can be offset and even more than offset by revenue recycling, in particular the reduction of social security contributions on labour income. We conclude that the different options for recycling revenue from auctioning permits should be considered when assessing the adverse distributional effects of the EU ETS.

2 Data and Methodology

We obtain direct CO_2 emissions per production sector from the German Environmental Account (Statistisches Bundesamt, 2010a). Combining this information with the German Input-Output Accounts (Statistisches Bundesamt, 2010b), we are able to calculate the CO_2 intensity of each sector covered by the EU

[1] During this third phase, for the first time, a substantial share of emissions permits is auctioned: more than 50% as compared to only 4% during the second trading period (2008-2012) (European Commission, 2010b, 2010c).

ETS[2] and predict the percentage price increase for all sectors following an assumed average carbon price of €25 during Phase 3 of the EU ETS,[3] both directly incurred by installations covered by the EU ETS and indirectly by sectors using CO_2 intensive goods as an input to production. Both data sets reflect emissions and industry structures for the year 2007. The production sectors are then aggregated to 25 groups of consumption goods, such as electricity, food and beverages and clothing. Consistent with the literature, we assume perfectly elastic supply and hence 100% cost pass-through to consumers.[4]

We focus on the impact of price increases in the electricity sector, both directly in the form of higher electricity bills for consumers and indirectly through a whole range of products that use electricity as an input to production. The rationale for focusing on the electricity sector is twofold. First, the electricity sector is responsible for 65% of emissions under the EU ETS. It is the only sector, which has to buy 100% of the permits from 2013 onwards. Other sectors, such as iron, steel, cement, lime and glass, are still granted free allocation on the basis that they might be susceptible to international competition and are not expected to be able to pass-through the full cost of carbon (European Commission, 2010a).[5] This assumption is also consistent with revenue-neutrality of the policy: The full burden incurred by households through price increases via the EU ETS is recycled back to them. Otherwise one would have

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[2] The EU ETS covers around 50% of European CO_2 emissions and around 12,000 individual installations in the energy and most industrial sectors, 1,700 of which are located in Germany. Installations covered include power stations and other combustion plants, oil refineries, coke ovens, iron and steel plants and factories producing cement, glass, lime, bricks, ceramics, pulp, paper and board. In 2012, aviation will come under the scheme and from 2013 onwards petrochemicals, ammonia and aluminum will also be covered, as well as the capture, transport and storage of CO_2.

[3] Even if earlier price forecasts for EU ETS permits (European Commision, 2008) have recently been revised downwards, an average price of €25 during the third trading period seems reasonable (Point Carbon, 2011) and has also been used in other studies (Löschel et al., 2011).

[4] This assumption might overstate regressivity, which is reduced if some of the incidence is passed back to factors of production (Metcalf et al., 2010).

[5] Additionally, we assume that the aviation sector will be able to pass costs forward to consumers, as all air travel into and out of the EU is covered by the scheme.

to infer how households would compensate for the burden imposed on them over and above the amount of revenue recycled.[6]

Figure 1 Percentage price increase for 25 groups of consumption goods

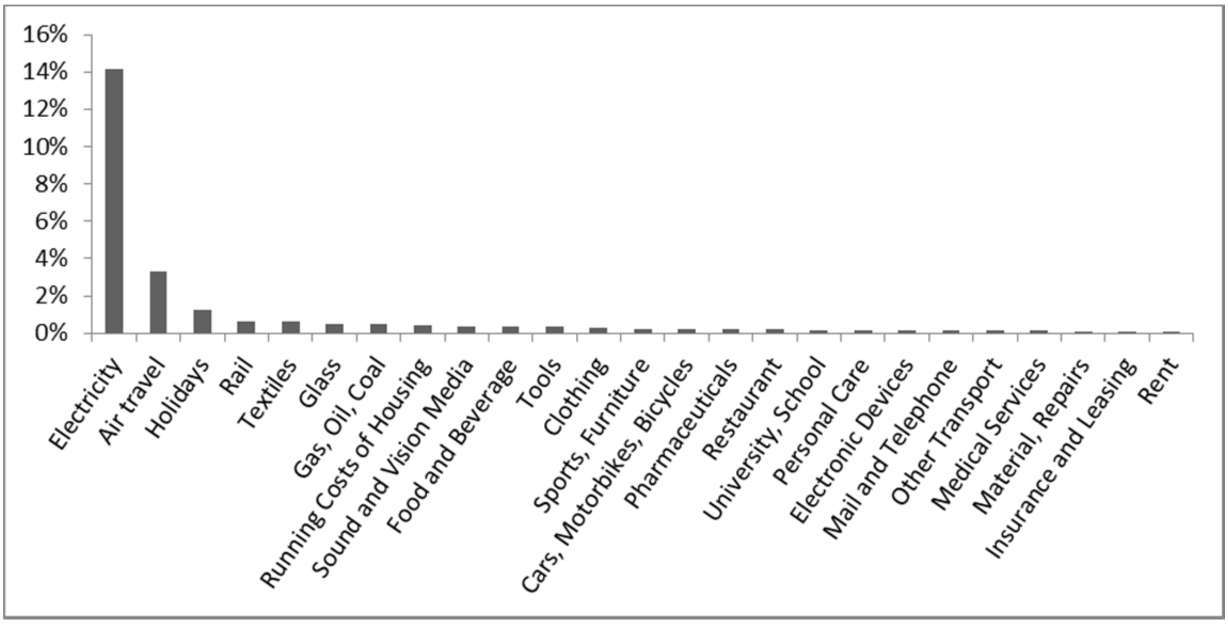

Figure 1 details percentage price increases for the 25 consumption groups. With an increase of 14% the effect is most pronounced for household consumption of electricity,[7] followed by the air travel sector, which is also expected to pass on the costs of compliance to consumers. To put this results into perspective, it should be noted that in 2007 already 20% of the electricity price consisted of environmental taxes, and a further 16% of the value added tax (VdEW Baden-Württemberg, 2007).

[6] Please refer to the Appendix for sensitivity analysis of the impact, where this assumption is relaxed and all EU ETS sectors pass costs forward to consumers.

[7] The price increase might in fact be even more pronounced as electricity prices are determined according to marginal plant (Matthes, 2008), which, in Germany, is an emissions-intensive, coal-fired power plant. At the same time, the EU ETS is expected to induce a shift away from emissions-intensive fuels, which might counteract this effect.

For all other sectors the price increase following the EU ETS is in the range of inflation.[8]

The German Income and Expenditure Survey (EVS) (Statistisches Bundesamt, 2011) is an administrative data source and contains detailed information on income sources and expenditure patterns of households, as well as information on other sociodemographic characteristics, such as social status and age of the household members. The Survey is published every five years and households are observed one quarter reporting individual income and household level expenditures. We use 2008 data and update the monetary variables including consumption spending patterns to 2013. For this purpose, we pool the waves 1998, 2003 and 2008 and run regressions on sociodemographics and time trends.[9] Table I shows average expenditure and income for the households included in the EVS. Using expenditure as a proxy for lifetime income (cf. Poterba 1991), we sort households into equivalent expenditure deciles.

We estimate the first-round effects of the EU ETS on German households under the assumption of a permit price of €25 by calculating the percentage increase in expenditure necessary to retain the consumption level of all 25 groups of consumption goods. The calculation of first-round effects takes into account both the direct effect on household expenditures incurred through a higher price for electricity and the indirect effect through consumption of products that use electricity as an input to the production process, but does not account for substitution and income effects induced by changes in the relative prices of consumption goods.

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[8] A household's use of motor fuels and gas and oil for heating purposes are not covered by the EU ETS but subject to alternative measures in the EU.

[9] We also considered updating the industry-level data set to 2013. However, assumptions on the development of emissions and economic activity for all 72 sectors included in the German Input-Output Tables would have been necessary. As these two variables might well decouple to some extent during the next years, using 2007 data seemed to be favourable for consistency reasons.

Table I Average monthly expenditure and income of net equivalent expenditure deciles of the 2008 German Income and Expenditure Survey (in €)

Net equivalent expenditure decile	Average expenditure	Average net income	Average electricity expenditure
1	924	1300	60
2	1271	1807	68
3	1508	2209	69
4	1736	2592	70
5	1945	2877	73
6	2153	3152	75
7	2414	3527	78
8	2709	3890	80
9	3202	4527	85
10	5149	5729	94
Average	2287	3139	75

3 First-Round Effects

Figure 2 shows first-round effects, divided into the direct effect of the increase in the price of electricity and the indirect effect on other goods. As can also be seen from Table II, the total impact of the EU ETS on German households is clearly regressive. This result is driven by the regressive effect of direct electricity consumption, while the indirect effect is distributed progressively, a result that has previously been noted in the literature (Bull and Hassett, 1994; Casler and Rafiqui, 1993; Hassett, Mathur and Metcalf, 2009). Affecting less than 1.1% of household expenditure for all deciles, the overall effect is fairly moderate.

Figure 2 Initial impact of the EU ETS on German households, as % of household expenditure

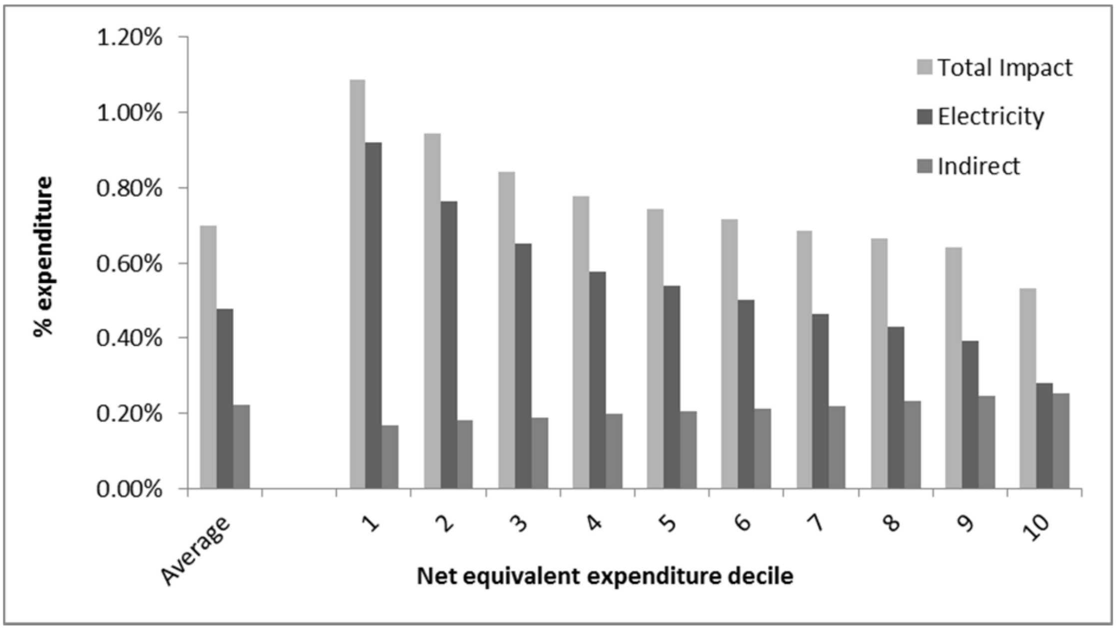
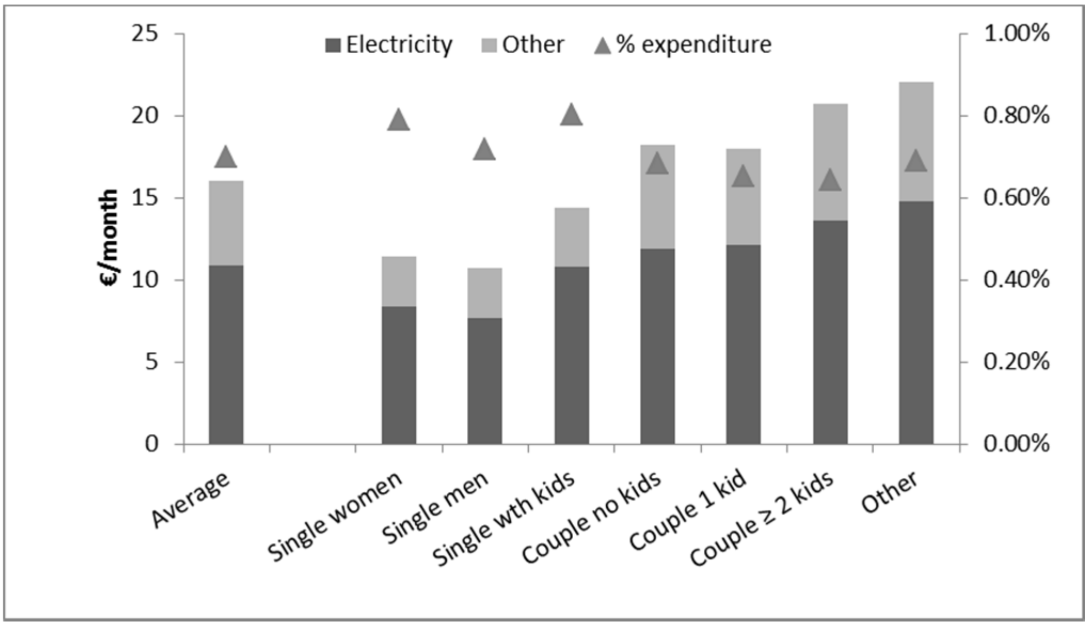


Figure 3 further illustrates this result by calculating impacts in monetary terms for different household types. On average, German households face additional costs of €16/month. Looking at the share of expenditure affected, we see that the effect is roughly proportional for all household types, although somewhat larger for single women and singles with kids.

Table II Initial impact of the EU ETS on German households, as % of household expenditure

Net equivalent expenditure decile	Total Impact	Electricity	Indirect
1	1.09%	0.92%	0.17%
2	0.95%	0.77%	0.18%
3	0.84%	0.65%	0.19%
4	0.78%	0.58%	0.20%
5	0.74%	0.54%	0.21%
6	0.72%	0.50%	0.21%
7	0.68%	0.46%	0.22%
8	0.66%	0.43%	0.23%
9	0.64%	0.39%	0.25%
10	0.53%	0.28%	0.25%
Average	0.70%	0.48%	0.22%

Figure 3 Monetary impact of EU ETS on selected household types



As our analysis does not incorporate behavioural change on the part of the household and therefore implicitly assumes price elasticities of zero for all consumption goods affected, it is best suited for a short-run view and small price changes and can serve as an upper bound to the estimation of the impact. This is also consistent with the assumption that only the electricity and aviation sectors will be able to pass through the costs of carbon in the short term. Neglecting behavioural effects can lead to overestimation of the regressivity of the policy (West and Williams 2004). However, it could be argued that since we are using 2008 data (and then further updating it), this data set could already incorporate a behavioural response to the EU ETS, since households might already have reacted to the EU ETS, which has been running since 2005 (cf. Wier et al. 2005 who use a similar argument for the Danish CO_2 tax). The effect on the expenditure for electricity would be twofold: The share would be smaller since households have reduced their consumption of electricity. The share (in monetary value) would be larger, since electricity has already become more expensive. These two effects might well be counteracting.

4 Role of Revenue Recycling

In this section, we return the revenue obtained by the German government through the auctioning of emissions allowances via lump-sum rebates and as a reduction in social security contributions (SSC). The estimated yearly revenue is €7.5 billion, equivalent to the amount of permits the electricity sector requires times a carbon price of €25.[10] With this amount we are able to reduce the social security contributions rate by 0.8 percentage points or provide a lump-sum transfer of 94€ per person in the household.[11] As a point of comparison, as a result of the environmental fiscal reform, the German government generated revenues of roughly €17 billion per year (€9 billion from households directly and another €8 billion from industry) and was able to reduce SSC by 1.6 percentage points (Deutscher Bundestag, 1999).

Figure 4 shows the impact the EU ETS has on German households if all of the revenue is recycled back (i) as lump-sum rebates (ii) as a cut in the rate of social security contributions. Both measures reduce the impact of the reform on German households significantly, but while the lump-sum rebate makes the EU ETS progressive, a reduction in social security contributions retains the regressivity of the policy. Table III details the impacts as a percentage of household expenditure along the equivalent expenditure deciles. In case revenues are fed back as lump-sum rebates, lower income deciles gain from the EU ETS, while for a reduction in social security contributions high income deciles gain.

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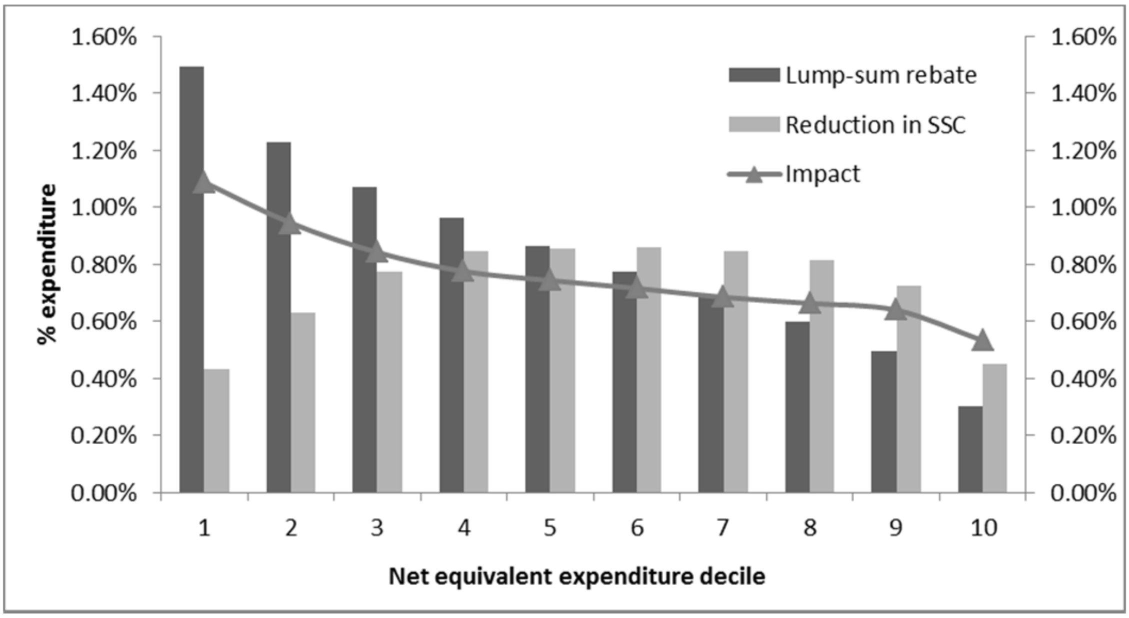
[10] Löschel et al. (2011) estimate auctioning revenues in 2013 of €6.4 billion rising to €8.1 Mio billion. Therefore, an average auctioning revenue of €7.5 billion seems reasonable.
[11] The case for targeted revenue recycling schemes rather than revenues being absorbed by the general budget can be made on the basis that it is likely to increase public support for the policy in question (see, for example, Kallbekken, Kroll and Cherry, 2011, who derive this result in their experiments).

Figure 4 Impact of the EU ETS and revenue recycling on German households, as % of household expenditure



This result hinges on the fact that social security contributions are deducted from work income. Therefore, a reduction in the rate of social security contributions does not benefit those households that do not have employment income. These households are usually located in the lower deciles of the income distribution. At the same time, an upper threshold for social security payments exists, which implies that the impact is relatively smaller for those households earning more than this threshold, typically in the high income deciles. Finally, the self-employed do not contribute to the social security system and hence do not benefit from a reduction of contributions.

Table III Impact of the EU ETS on German households after revenue recycling

Net equivalent expenditure decile	Net impact after lump- sum rebate	Net impact after reduction in SSC	Gross impact
1	-0.41%	0.65%	1.09%
2	-0.28%	0.31%	0.95%
3	-0.23%	0.07%	0.84%
4	-0.19%	-0.07%	0.78%
5	-0.12%	-0.11%	0.74%
6	-0.06%	-0.14%	0.72%
7	-0.01%	-0.16%	0.68%
8	0.06%	-0.15%	0.66%
9	0.14%	-0.09%	0.64%
10	0.23%	0.08%	0.53%

Table IV displays inequality measures before the EU ETS, for the gross impact without revenue recycling, and for the net impacts after a lump-sum rebate and a reduction in social security contributions respectively. Inequality is highest in the cases of no revenue recycling and can be reduced by both forms of revenue recycling. After recycling as lump-sum rebates, inequality is even reduced compared to the status quo. However, the changes are very small and not statistically significant.

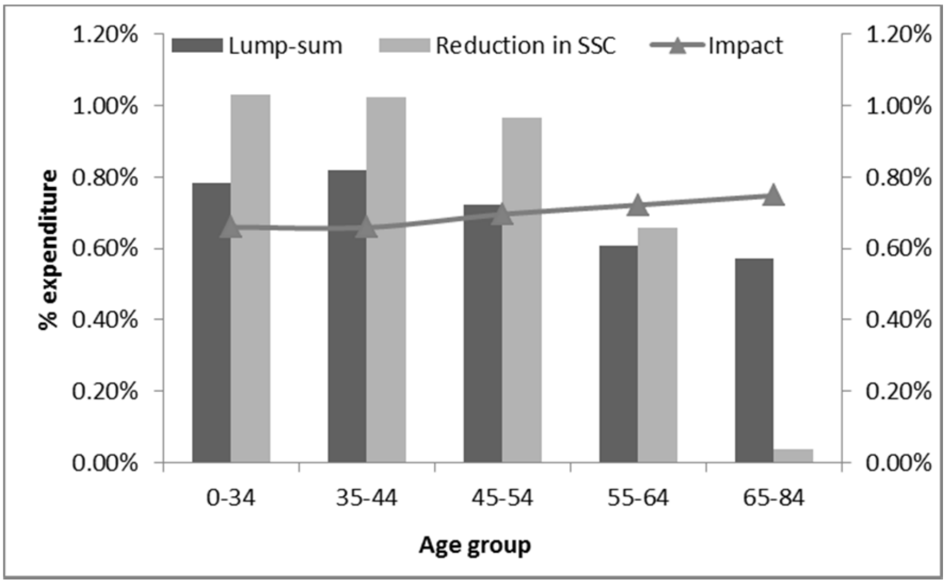
Table IV Inequality measures for the impact of the EU ETS with revenue recycling (using equivalent weights)

	Status quo (before EU ETS)	Gross impact (no Revenue Recycling)	Net impact after lump-sum rebate	Net impact after SSC reduction
Gini	0.2612	0.2620	0.2602	0.2617
Theil	0.1233	0.1241	0.1224	0.1235
GE(1)	0.1134	0.1142	0.1123	0.1142
GE(2)	0.1628	0.1639	0.1616	0.1627

Although the recycling of revenue in the form of a reduced rate of social security contributions does not seem to alleviate the regressive nature of the EU ETS as much as lump-sum rebates do, this form of revenue recycling may have the additional benefit of reducing existing distortions elsewhere in the taxation system. This trade-off between efficiency and equity considerations has previously been noted in the literature (Williams and Parry, 2010).[12]

[12] On a different note, MacKenzie and Ohndorf (2012) suggest that that even if distortions in the taxation system are reduced through revenue recycling, costly rent-seeking behaviour under instruments that generate revenues may outweigh this positive effect.

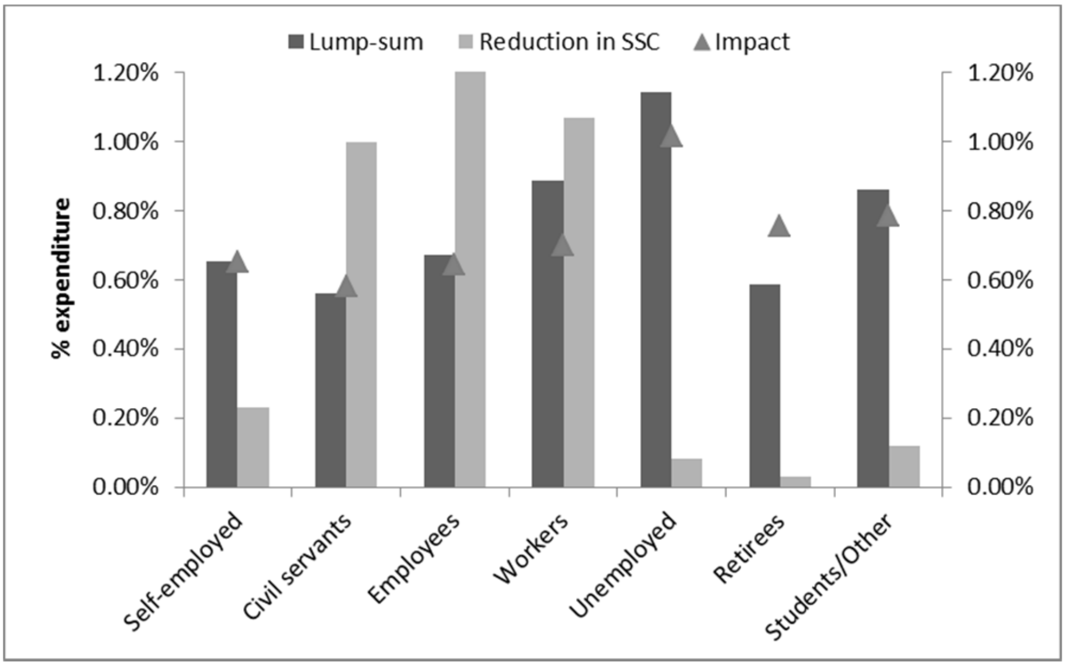
Figure 5 Impact of the EU ETS and revenue recycling on different age groups, as % of household expenditure



Other dimensions exist, along which distributional effects of a policy can be assessed. As Figure 5 shows, older people in Germany are particularly impacted by the EU ETS. They spend a relatively large share of their expenditure on goods affected by price increases through the EU ETS and do not gain as much from rebates. Especially if revenues are distributed as reductions to social security contributions, one can see the "pensioner effect," i.e. as 65 is the official retirement age in Germany, most of those people do no longer contribute to the social security system and hence to do not benefit from the rate reduction. However, Parry et al. (2006) also note that indexed transfer payments, such as social security benefits, will adjust if the price of consumption goods increases as a reaction to emissions trading, however, further research is needed in order to assess if this compensates for a substantial amount of the price increase.

Finally, looking at the impact the EU ETS has on people of different social status, Figure 6 shows that a reduction in social security contributions favours civil servants, employees, and workers. If revenues are returned in a lump-sum fashion nearly all groups are, on average, compensated for the impact caused by higher prices, except for the retirees, who again, seem to be particularly disadvantaged.

Figure 6 Impact of the EU ETS and Revenue Recycling on people of different social status, as % of household expenditure



In December 2010 the German government passed a law setting up a new Energy and Climate Fund, which will receive most of the proceeds generated through the EU ETS auctions and will be used to finance national energy efficiency and renewable energy projects and international climate protection measures in accordance with the German Energy Concept (BMWI and BMU, 2010). Although the German environmental fiscal reform, which was enacted in 1999, was used to finance a decrease in the rate for social security contributions and proposals in the U.S. (Metcalf, Marthur and Hassett, 2010) and Australia (Hatfield-Dodds et al., 2011) include elaborate household assistance, the German government has not formulated any such plan for the EU ETS revenue. Using the revenue for clean energy and climate protection measures, as is envisaged by the German government, does not directly impact the income of households. Whether the benefits of such a policy accrue to low- and high-income households alike is a point of disagreement (see Fullerton, 2008, for an overview of the possible effects).[13] However, if those spending programmes were targeted directly at low income households, e.g. via energy efficiency schemes, the initial regressive effect could also be offset.

5 Conclusion

The potentially adverse distributional effects of pollution control policies in general and the European Emissions Trading System (EU ETS) in particular have received an increasing amount of attention during the past years. The ability to address those concerns will be material in shaping climate policy in the future.

We confirm the ex-ante expected regressive effect the EU ETS has on households. However, the initial regressive effect is both rather small in magnitude and can be offset and even more than offset by revenue recycling on the government part. This result puts into perspective concerns about adverse distributional effects of the EU ETS and should be taken into account when assessing the different options for revenue recycling of auctioning revenues from the EU ETS. To date, the German government has not announced clear plans of how the EU ETS revenue will be recycled. While using the auctioning revenue to fund climate protection measures seems reasonable, some of the revenue could indeed be used to offset adverse distributional effects and to improve the efficiency of the taxation system, thereby not only reaping additional benefits, but also making the policy more attractive to the public as a whole.

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[13] Furthermore, as Cremer, Gahvari and Ladoux (2003) point out, in order to fully assess implications of a more specific plan to recycle revenue for the income distribution among households, it is crucial to take account of the pre-existing distortions in the taxation system.

Overall, governments should (in keeping with considerations about the competitiveness of businesses), maximize auctioning revenue, so as to retain flexibility to use it in order to improve the efficiency of the taxation system and achieve distributional aims. Furthermore, the higher the price of emissions, the higher the auctioning revenue and the larger the opportunities for the government to use it to address distributional concerns. While the government cannot and should not influence the price of carbon directly, stringent emissions caps or price floors provide possibilities for ensuring a steady flow of revenue to the government.

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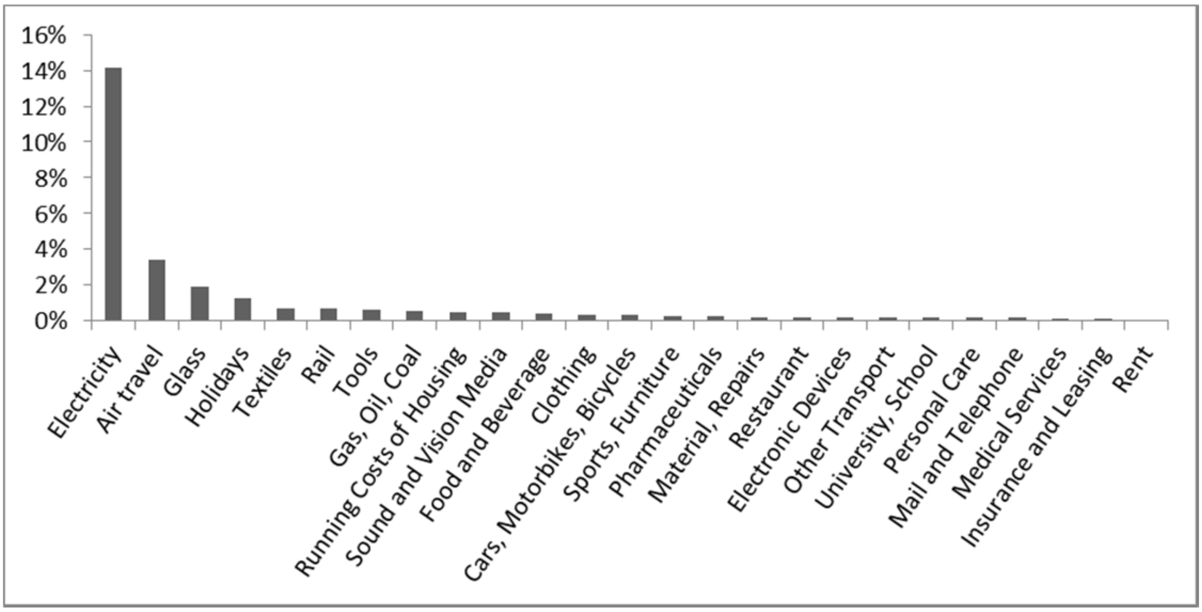
Appendix: Sensitivity Analysis

For this sensitivity analysis, we assume that all sectors covered by the EU ETS pass the full cost of carbon forward to consumers (and not just electricity and aviation sectors). The literature, in accordance with economic theory, assumes that the allocation methodology is indeed irrelevant for the rate of cost pass-through. Even if emissions permits are given out for free, they represent assets that could be sold if they would not have to be held to cover an installation's emissions. A firm is expected to add the opportunity cost of the forgone alternative use (i.e. selling of permits) to its production costs (Sijm, Neuhoff and Chen, 2006).

Figure 7 Sensitivity analysis of percentage price increase in 25 groups of consumption goods (assumption: all ETS sectors pass costs forward to consumers)



As Figure 7 shows, the price increase for electricity is still by far the largest, also in this sensitivity scenario. Therefore, conclusions regarding the impact of the EU ETS on consumers remain very similar to the above analysis. As Table V and Figure 8 show the overall effect is now larger, while the regressive nature of the total effect and the progressive nature of the indirect effect remain. However, in this setting, where only part of the burden imposed on households is obtained by the government in the form of auctioning revenue, companies are expected to generate considerable windfall profits. Parry (2004) who approximates the impact of those windfall profits on the income distribution by looking at share holdings across income deciles, concludes that in such a setting emissions permits that are given out for free are especially regressive.

Figure 8 Sensitivity Analysis of initial impact of EU ETS on German Households as % of expenditure (assumption: all EU ETS sectors pass costs forward to consumers)

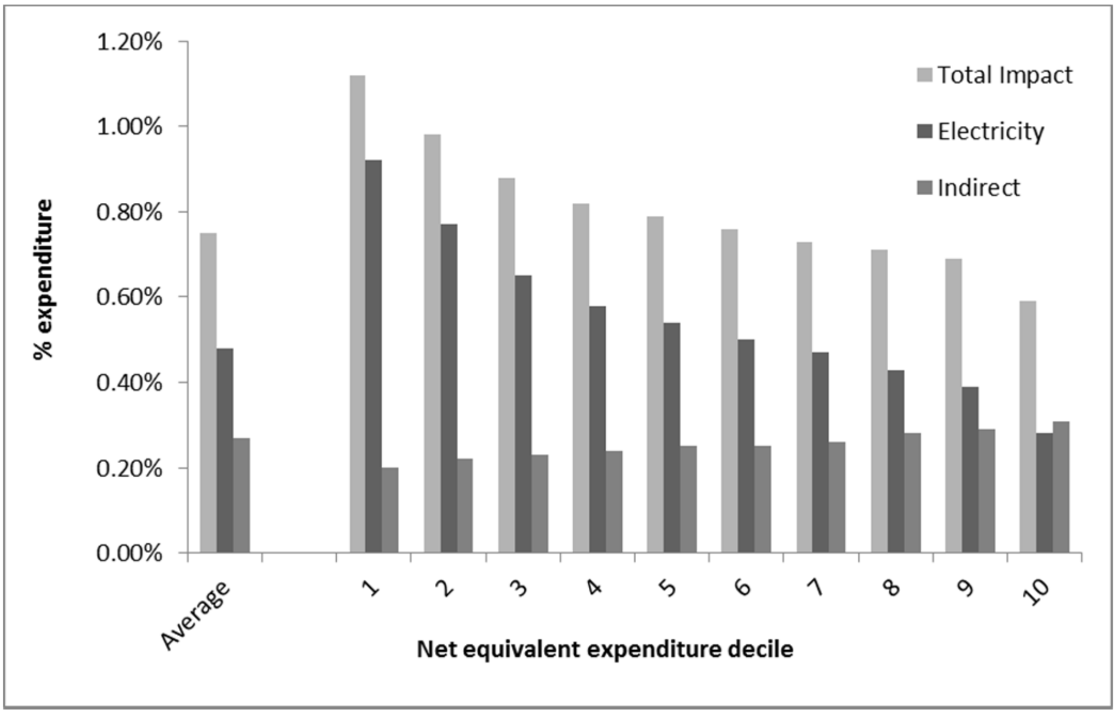


Table V Sensitivity analysis of initial impact of EU ETS on German Households as % of expenditure (assumption: all ETS sectors pass costs forward to consumers)

Net equivalent expenditure decile	Total Impact	Electricity	Indirect
1	1.12%	0.92%	0.20%
2	0.98%	0.77%	0.22%
3	0.88%	0.65%	0.23%
4	0.82%	0.58%	0.24%
5	0.79%	0.54%	0.25%
6	0.76%	0.50%	0.25%
7	0.73%	0.47%	0.26%
8	0.71%	0.43%	0.28%
9	0.69%	0.39%	0.29%
10	0.59%	0.28%	0.31%
Average	0.75%	0.48%	0.27%

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